An Experimental Study of the Holdout Problem in a Multilateral Bargaining Game

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Abstract

When an economic exchange requires agreement by multiple independent parties, the potential exists for an individual to strategically delay agreement in an attempt to capture a greater share of the surplus created by the exchange. This "holdout problem" is a common feature of the land assembly literature because development frequently requires the assembly of multiple parcels of land. We use experimental methods to examine holdout behavior in a laboratory bargaining game that involves multi-person groups, complementary exchanges, and holdout externalities. The results of six treatments that vary the bargaining institution, number of bargaining periods, and the cost of delay demonstrate that holdout is common across institutions and is, on average, a payoff-improving strategy for responders. Both proposers and responders take a more aggressive initial bargaining stance in multi-period bargaining treatments relative to single-period treatments, but take a less aggressive bargaining stance when delay is costly. Nearly all exchanges eventually occur in our multi-period treatments, leading to higher overall efficiency relative to the single-period treatments, both with and without delay costs.

1. Introduction

When an economic exchange requires agreement by multiple independent parties, the potential exists for an individual to strategically delay agreement in an attempt to capture a greater share of the total surplus created by the exchange. This “holdout problem”, as it has been called, is a common feature of the land assembly literature (Nosal 2007; Miceli and Sirmans 2007; Miceli and Segerson 2007; Menezes and Pitchford 2004a and 2004b; O’Flaherty 1994; Strange 1995; Eckart 1985; Coase 1960) because land development and urban renewal frequently requires the assembly of multiple parcels of land. Similarly, the production of new products may require the use of multiple intermediate patented goods. Strategic delay and holdout have also been studied in other contexts, including debt restructuring that requires acceptance of an exchange offer by multiple creditors (Miller and Thomas 2006; Hege 2003; Datta and Iskandar-Datta 1995; Brown 1989), and wage negotiations (Houba and Bolt 2000; van Ours 1999; Gu and Kuhn 1998; Cramton and Tracy 1992). In each case, it may be difficult or impossible to distinguish strategic holdout behavior from more genuine disagreement arising because a buyer’s offer is below a seller’s reservation price.

Because of the potentially large inefficiencies arising from failed exchanges in land assembly, the holdout problem has been cited as one justification for eminent domain, the legal power of the state to expropriate private property without the owner’s consent.[1] Eminent domain has traditionally been used in the United States to acquire land for public projects, but has been increasingly used to facilitate, with considerable controversy, the transfer of property from one private owner to another.[2] In most cases eminent domain is accompanied by a requirement that just compensation be paid, generally interpreted to be fair market value.[3]

From an economic perspective, whether the application of eminent domain can be viewed as efficient depends on the relative values attached to the parcels by the parties involved in the exchange and the costs associated with delay. Difficulties associated with estimating these parameters using field data complicate the identification and measurement of holdout behavior, and for this reason previous research on the land assembly problem has been primarily theoretical.[4] This paper uses experimental methods to examine holdout behavior in laboratory bargaining games that involve multi-person groups, complementary exchanges, and holdout externalities. While there is a large literature on laboratory bargaining behavior, the vast majority of these studies examine behavior in two-person games involving a single "buyer" (or proposer) and a single "seller" (or responder). While one party may "holdout" in multi-period bargaining environments (e.g. Gneezy, et al 2003; McKelvey and Palfrey 1995) in hopes of receiving a larger payoff, there are no co-dependent transactions. Thus, while there may be costly delay in simple two-person bargaining environments, no holdout externalities of the kind commonly associated with land-assembly type problems are present. Some experimental analyses of Coasian bargaining (e.g. Hoffman and Spitzer 1986; Harrison, et al 1987) include larger groups, but lack the critical interdependence of transactions necessary for holdout externalities. This research, therefore, provides an important link between the theoretical analysis of holdout developed extensively in the land assembly literature, and the experimental analysis of behavior in bargaining games.

We distinguish the "holdout" problem from a related "hold-up" problem (Dawid and MacLeod 2008; Ellingsen and Johannesson 2004; Klein, et al 1978; Williamson 1975), which refers to the case when an upstream agent must make a costly investment in the first stage of a game that is only of use to a single downstream agent in the second stage. In such cases, a first-

period investment can be held up in a second period by the downstream agent in an attempt to extract a greater share of the total surplus generated by the investment. The *ex post* commitment problem inherent in the hold-up problem can lead to inefficiently low investment in the first stage of the game.

If a land assembler must purchase a set of required parcels sequentially, then initial purchases may represent an investment that is not easily reversible, or reversible only at a considerable loss to the assembler. In such cases, both a hold-up and a holdout problem exist in the bargaining game as landowners who have not yet sold may *ex post* exploit the assembler's previous investment. However, if the assembler can write contingent contracts, such that no purchases occur unless agreement is reached with all landowners, then only a holdout problem exists. We model only the latter situation.

We examine the holdout problem with six experimental treatments that vary the bargaining institution, number of bargaining periods, and the cost associated with delay. Our results demonstrate that holdout is common across institutions and is, on average, a payoff-improving strategy for responders, despite theoretical predictions. Initial offers-to-buy decrease and demands-to-sell increase in multi-period bargaining treatments relative to a single-period treatment. Responders are also more likely to reject a given offer in multi-period treatments. Imposing delay costs causes offers-to-buy to rise, demands-to-sell to fall, a higher probability of responders accepting a given offer or demand, and less overall holdout. Importantly, nearly all exchanges eventually occur in our multi-period treatments, leading to higher overall efficiency relative to the single-period treatments, both with and without delay costs.

However, caution should be exercised when considering the implications of our results for the eminent domain question. Our treatments have a very small number of sellers and

complete and perfect information, characteristics that are unlikely to be present in the field. Therefore, the current study should be viewed as an initial empirical investigation of holdout behavior and costs, leaving many important questions unanswered. The potential for eminent domain to improve social welfare in the field depends upon the costs of delay relative to the costs of potentially inefficient land transfers and the disincentive effects of weakened property rights when eminent domain is used; the prospect of eminent domain may also *increase* bargaining delay if buyers expect to pay less under eminent domain transfer compared to the free market transfer of property. For example, Munch (1975) demonstrates that the prospect of eminent domain tends to reduce some property values, leading to eminent domain prices below market value. These issues can only be resolved through further study.

The remainder of the paper is organized as follows. In section 2 we describe the basic model that motivates the experimental design. Section 3 presents the experimental treatments and provides equilibrium predictions. Experimental results are given in section 4 followed by concluding remarks in section 5.

2. Modeling Framework

Following Menezes and Pitchford (2004b) and Miceli and Segerson (2007), consider a simple model in which a single risk-neutral agent (the "buyer") wishes to purchase N complementary units of a good from N other independent, risk-neutral agents (the "sellers"). The units can be interpreted as intermediate inputs into the production of a large project. Each seller i has one unit for sale and incurs a cost c_i for this unit. The value of the project to the buyer is V if N input units can be acquired, but is zero otherwise. Let the buyer's valuation and the sellers' costs be such that

$$\sum_{i=1}^{N} c_i < V \tag{1}$$

indicating that there is an economic surplus generated by the project.

Assuming N input units can be acquired, the payoff to the buyer is

$$(V - \sum_{i=1}^{N} p_i) \tag{2}$$

where p_i is the price paid for unit i, and each seller i receives a payoff $(p_i - c_i)$. Assume the buyer may write contingent contracts such that no sales occur (and, therefore, all parties receive a payoff of zero) if any of the required input units are not purchased.

We suppose that bargaining takes place between the buyer and the sellers over several periods. Delay is costly such that payoffs are reduced by a factor δ (where $0 \leq \delta \leq 1$) for each additional period, on average, needed for agreements to be reached. For example, payoffs would be reduced by δ if all agreements were reached in the second period, reduced by 2δ if agreements were reached in the third period, and so on. This is equivalent to assuming that the economic surplus $(V - \sum_{i=1}^{N} c_i)$ shrinks by δ from period to period.

We recognize that our approach to delay costs is one of many that could be chosen. Our intent here is to model a symmetric holdout externality. Therefore, a rejection by a responder of any offer or demand imposes a cost on other bargaining parties regardless of the choices of other responders. This is consistent both with the nature of contingent contracts and the real possibility that bargaining involves transaction costs that are incurred each time an offer or demand is made. An alternative assumption would be to model delay costs as a weakest link. That is, all payoffs are reduced by $(t-1)\delta$ where t is the actual round in which the last needed offer is accepted. While

qualitatively similar to our design, this design would not impose a holdout externality by the first responders to accept an offer or demand. The externality would be driven entirely by the last responder to accept an offer or demand. This is an interesting alternative and would be consistent with the idea of "holdout" as referring to an individual bargaining party, whereas our design models "holdout" as a strategy that can be adopted by any or all responders at once.

3. The Experiment

We use one-sided ultimatum-type bargaining rather than more complex multi-party Nash bargaining[5] or bargaining with alternating offers. Nash bargaining does not allow one party to holdout by explicitly rejecting an offer, which is of primary interest in the current project. It would also place greater importance on risk preferences and is difficult to implement experimentally because of the likelihood of off-equilibrium decisions. We also avoid bargaining with alternating offers because it introduces an additional incentive to reject an offer in order to become the proposer. To examine the importance of being the proposer, we compare separate treatments in which buyers make repeated take-it-or-leave-it *offers* to buy in some treatments, and sellers make repeated take-it-or-leave-it *demands* to sell in other treatments. Responders decide only whether to accept or reject an offer or demand.

Experimental treatments

All treatments are conducted with one buyer and two sellers, using z-Tree software (Fischbacher 2007). We conducted six treatments in a 3x2 design. Two treatments are single-period bargaining games and four treatments are (up to) ten-period bargaining games. Two of the latter treatments have costless delay (that is $\delta = 0\%$) and two treatments have costly delay. In these costly delay treatments $\delta = 10\%$. That is, all payoffs are reduced by 10% for each

additional period, *on average*, needed for agreements to be reached. For example, if one buyer is making repeated offers to two sellers, all participants' payoffs are reduced by 5% each time a seller rejects an offer. If both sellers accept in the first period, payoffs are not reduced. If both accept in the second period, all payoffs are reduced by 10%. If one seller accepts in the first period and the other in the third period, payoffs are reduced by 10%, and so on. Thus, holding out generates a payoff-reducing externality regardless of the decisions of the other subjects.

The six total treatments are generated by conducting the (1) single-period, (2) multi-period with costless delay, and (3) multi-period with costly delay protocol (our *Baseline* protocol) with (1) buyers making *offers* in the first three treatments, and (2) sellers making *demands* in the other three treatments. In each case, the party receiving the offer or demand chooses to accept or reject. If any party rejects an offer or demand in the single-period treatments (or fails to accept an offer or demand by period ten in the multi-period treatments) then all bargaining parties in that group receive a payoff of zero. For the multi-period treatments, if a responder rejects an offer or demand, the proposer is able to make a new offer or demand for up to a maximum of ten periods. Unlike in the Gneezy, et al (2003) experiments, proposers in our experiment are not constrained to increase their offers (or reduce their demands) upon a rejection.

Valuations and costs are common knowledge. The buyer's valuation is $V = \$ 90$. The sellers' costs are symmetric such that $c_1 = c_2 = \$ 30$. This results in an economic surplus of $30 that may be divided between the three participants. All offers / demands (within a period) are made simultaneously. Once a seller accepts an offer from the buyer, or has a demand accepted by the buyer, that seller makes no additional decisions. Sellers do not observe offers or demands made for other sellers' units, but are informed of the amount of any accepted offer or demand.

Subjects are informed of their experimental earnings (adjusted for any delay costs) plus a $10 show-up fee and paid privately, in cash at the end of the experiment.

Equilibrium predictions

Assuming complete information and that each agent seeks to maximize his monetary self-interest, the well-known unique subgame perfect Nash equilibrium to the single-period ultimatum game is for the proposer to offer the smallest share of the surplus possible, and for the responder to accept it. Let b_i represent a buyer's offer to buy and d_i represent a seller's demand to sell a particular unit. In the multi-seller design used here, this implies:

Proposition 1: When the buyer makes ultimatum offers, the buyer offers each seller her cost. That is, $b_i = c_i \quad \forall i$.[6]

Proposition 2: When sellers make ultimatum demands, multiple equilibria exist. The set of equilibria are characterized by $\sum_{i=1}^{N} d_i = V$ and $d_i \geq c_i \; \forall i$.

Proposition 3: Responders should accept any offer or set of demands that leaves them with a non-negative surplus.

Proposition 1 is the standard equilibrium prediction for proposer behavior which implies here that the buyer captures all (or nearly all) of the surplus. Proposition 2 characterizes a Nash-like bargaining outcome from the perspective of sellers. Proposition 3 follows from the assumption that a positive payoff is preferred to a zero payoff.

Propositions 1 – 3 are unaffected by the addition of multiple bargaining periods, with or without costly delay. Responders cannot increase their payoff by rejecting an offer or set of demands that leaves them with a non-negative surplus, because there is nothing in the standard game-theoretic predictions of proposers' behavior to indicate that they, in equilibrium, should offer a greater share of the surplus following a rejected offer or demand.

The wealth of research in single-period, ultimatum-type bargaining games has consistently demonstrated that behavior does not conform to the standard predictions based on the simple assumption of maximizing one's monetary self-interest. However, this research provides little guidance on what we should expect in a multi-period bargaining game of the type presented here. In the multi-period treatments responders *may* holdout in the *hope* of obtaining a larger share of the surplus. This possibility raises some interesting behavioral questions. Do either initial or subsequent offers or demands in a multiple-period game differ from those in a single-period game? Are responders more likely to reject a given offer or demand in a multi-period game compared to the single-period game? How do proposers in a multi-period game respond to a rejection? Is holding out a payoff-improving strategy, on average? How is the duration of holdout affected by the cost of delay? Do the rate of disagreement (i.e. failed exchanges) and the efficiency of exchange differ in the multi-period game compared to the single-period game?

4. Results

Subjects for all treatments were undergraduate volunteers at Gettysburg College. Subjects participated anonymously via computer. Five hundred and twenty two student subjects participated in 30 sessions for a total of about 30 bargaining groups per treatment.

Table 1 presents offer, demand, and earnings results from the six treatments. The table gives the mean first-period offer or demand, as well as the mean real final payoff for buyers and sellers. Real payoffs are adjusted for any delay costs. For comparison, the table also gives the mean buyer and seller earnings that would have resulted had all first-period offers or demands been accepted.

[Insert Table 1 here]

Table 2 reports the marginal effects from a probit regression analysis of responders' first-period decisions. The response variable is defined such that *accept = 1*, *reject = 0*.We analyze the buyer-offer and seller-demand protocols separately, controlling in each case for the offer or demand and including two dummy variables indicating that the treatment was single-period or had costless delay. The default *(Baseline)* is the multi-period costly delay treatment.

[Insert Table 2 here]

Table 3 provides rejection, holdout, and efficiency statistics. Holdout is calculated as the mean number of rejected offers or demands per group. Efficiency is calculated as the actual total group earnings divided by the maximum possible (which is $30 per group, the value of the original surplus).

[Insert Table 3 here]

A large number of comparisons can be made based on the results in Tables 1, 2, and 3. To keep these comparisons most clear, we discuss each in a separate subsection below.

Behavior versus equilibrium predictions

Behavior is qualitatively, but not strictly, consistent with the game-theoretic predictions, which is consistent with general findings from the many ultimatum bargaining experiments that have been conducted to date. That is, using an equal split of the surplus as a natural focal point (offers/demands of 40), first-period offers and earnings favored the buyer in all of the buyer-offer treatments, but favored the sellers in all of the seller-demand treatments. These differences are statistically significant (in the hypothesized direction) in every case.[7]

First-round offers and demands across treatments

An important result of this study concerns the impacts that multi-period bargaining and costly delay have on initial offers or demands, as this likely determines, in part, the decisions of responders as well as the path of subsequent offers or demands. On average, first-period offers from the buyer-offer with costless delay treatment were $2.34 lower than in the single-period buyer-offer treatment, and the difference is statistically significant.[8] Similarly, first-period demands were, on average, $5.09 higher than in the single-period seller-demand treatment.[9]

Additionally, imposing costly delay caused average initial offers to rise by $1.54, and initial demands to fall by $2.56, relative to the costless delay treatments, and the differences are statistically significant.[10]

Responders' first-period decisions

Similarly, it is important to understand how the number of bargaining periods and the cost of delay impact a responder's bargaining stance as well. Table 2 shows that, as expected, the size of the actual offer or demand is an important determinant of the probability of accepting an offer. The probability of a seller accepting a buyer's first-round offer increased by around 5.5% for each $1.00 increase in the offer, while the probability of a buyer accepting a seller's demand decreased by 6.3% for each $1.00 increase in the demand. However, buyers and sellers alike were much more likely to accept a given offer or demand if there was only a single bargaining period - buyers were 58% more likely, and sellers were 37% more likely to accept in this case. However, both parties took a tougher bargaining stance when delay was costless. Buyers were 24% less likely to accept a given demand under costless delay, and sellers were 38% less likely to accept a given offer.

Figures 1 and 2 show the cumulative probability (resulting from the probit model) of a responder accepting a given first-period offer or demand over the entire range of offers and demands.

[Insert Figures 1 and 2 here]

The figures further support the result that responders took a much tougher bargaining stance when delay was costless versus costly, but were much more willing to accept a given offer or demand in the single-period treatments relative to the multi-period treatments.

Final earnings within treatments

In the single-period treatments, buyers' final earnings exceeded sellers' final earnings in the buyer-offer treatment,[11] but although sellers' earned more, on average, in the seller-demand treatment, the difference was not statistically significant. Interestingly, however, real final payoffs favored the buyer in all four of the multi-round treatments. This difference was statistically significant only in the buyer-offer with costly delay treatment.[12]

Final earnings versus first-round earnings within treatments

In all four multi-period treatments, the mean real earnings of the responder are higher than the mean first period offer or demands would have generated, and the differences are statistically significant in every treatment.[13] In other words, mean real offers to the responders rose in subsequent periods. This implies that with or without delay costs, holdout (that is, rejecting low offers or high demands) is, on average, a payoff-improving strategy for the responder in each treatment.

This result is particularly strong in the seller-demand treatments. Average first-period earnings for the buyer would have been very low in both treatments, and even negative in the seller-demand with costless delay treatment. Sellers face a difficult coordination problem in

these treatments, and made excessively high demands. In fact, over half of the buyers (18 out of 30) in this treatment effectively had negative offers in the first period as a result of the sellers' joint demands averaging $46.73, and had no choice but to reject at least one of the demands. The coordination problem was present, though not as severe, in the seller-demand with costly delay treatment, where about a third of buyers (9 out of 30) faced negative payoffs in the first period.

This result is further illustrated in Figures 3a through 4b which give the change in real offers by buyers to sellers (Figures 3a and 3b) or by the sellers to buyers (Figures 4a and 4b) following a rejection.

[Insert Figures 3a through 4b here]

Notice the tendency in Figures 3a and 3b for buyers' real offers to sellers to rise following a rejection, particularly in the early rounds. The result is even stronger for the seller-demand treatments. The change in sellers' joint demands following a rejection by the buyer resulted in a larger real surplus for the buyer in all but a few instances, even in the presence of costly delay.

Holdout and efficiency across treatments

As first-period offers decreased and first-period demands increased in the multi-period treatments relative to single-period treatments (and responders were more likely to reject a given offer or demand), the number of rejections increased dramatically, as illustrated in Table 3. Holdout was prevalent in all four multi-period treatments. Overall holdout was considerably higher in treatments without delay costs, with three to four times the number of rejected offers or demands per group compared to the treatments with delay costs. These differences were statistically significant.[14] There was no significant difference in holdout between the buyer-offer treatments compared to the seller-demand treatments. Nearly all exchanges eventually occurred

in our multi-period treatments, leading to higher overall efficiency relative to the single-period treatments, both with and without delay costs. Only one group in one treatment (seller-demand with costless delay) failed to reach an agreement during the ten-period limit.

5. Conclusion

The theory of holdout developed in the land-assembly literature is difficult to empirically evaluate due to the lack of reliable field data on buyer and seller valuations and delay costs. Our research provides an initial systematic empirical study of holdout behavior in multilateral bargaining environments by linking the theoretical analysis with the well-developed experimental literature on bargaining. In contrast to the existing experimental bargaining literature, our design utilizes multi-person groups with codependent transactions and delay costs that introduce a holdout possibility as well as a holdout externality.

In particular, we examine the behavioral responses of proposers and responders to changes in bargaining institutions, the number of bargaining periods, and the costs associated with delay. The results of a series of six treatments demonstrate that holdout is common across bargaining institutions and is a payoff-improving strategy on average, despite the presence of delay costs, in each of the treatments studied to date. As such, our results indicate that even if the holdout problem does not exist in theory (assuming payoff-maximizing bargainers), it may still exist in practice. The number of bargaining periods also had a significant effect on subject behavior. Initial offers-to-buy decrease and demands-to-sell increase in multi-period bargaining treatments relative to a single-period treatment. Compounding this problem is that responders exhibited a lower probability of accepting a given offer or demand in the early periods of the multi-period treatments. Thus, opportunities for additional bargaining may have led *both*

proposers and responders to take a more aggressive bargaining stance initially, with the recognition that offers or demands could become more generous in subsequent periods, if necessary. Imposing delay costs causes offers-to-buy to rise, demands-to-sell to fall, a higher probability of responders accepting a given offer or demand, and less overall holdout. Importantly, nearly all exchanges eventually occurred in our multi-period treatments, leading to higher overall efficiency relative to the single-period treatments, both with and without delay costs.

It would clearly be premature, however, to discount the potential welfare improvements that eminent domain might provide based on these findings alone. Substantial land-assembly-type projects in the field likely involve many more parties than in our experiment, as well significant information asymmetries, both of which are likely to increase bargaining delay and associated delay costs. The potential for eminent domain to improve social welfare in the field, however, depends on whether it actually reduces delay costs relative to voluntary transfer, a question that has yet to be adequately addressed theoretically, empirically, or experimentally. While their modeling framework is different than ours, Miceli and Segerson (2007) show theoretically how the threat of eminent domain can result in earlier agreements. Munch (1975), however, demonstrates empirically that the threat of eminent domain may depress property values, resulting in intentional delay on the part of the buyer and potentially high court costs associated with the eminent domain process. It would be interesting to examine how the background threat of eminent domain affects behavior in an experimental setting such as ours.

Therefore, the current study should be viewed as an initial empirical investigation of holdout behavior and costs, leaving many important questions unanswered. We recognize that potentially important features of real-world bargaining environments are absent, and we propose

to broaden the investigation to include environments with larger bargaining groups, competition between sellers, incomplete information about buyers' values and sellers' costs, and eminent domain threats. Furthermore, exploring the use of alternative bargaining institutions, such as alternating offers or Nash bargaining should be a fruitful avenue for future experimental research into behavior in multilateral bargaining situations.

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7. Tables

Table 1. Offer/demand and earnings results by treatment (standard deviations in parentheses)

Proposer	Treatment	Mean first period offer/demand	Mean buyer first period earnings	Mean seller first period earnings	Mean real final buyer earnings	Mean real final seller earnings	Number of groups
Buyer	Single Period	$36.62 (3.45)	$16.76 (6.66)	$6.62 (3.45)	$8.62 (8.60)	$4.48 (4.45)	N = 29
Buyer	Ten-period Costless delay	$34.28 (3.31)	$21.43 (6.26)	$4.28 (3.31)	$10.55 (5.25)	$9.72 (3.00)	N = 29
Buyer	Ten-period Costly delay	$35.82 (2.57)	$18.37 (5.08)	$5.82 (2.57)	$11.12 (5.67)	$7.24 (2.78)	N = 30
Seller	Single Period	$41.66 (4.71)	$6.68 (6.94)	$11.66 (4.71)	$6.94 (6.05)	$8.07 (5.67)	N = 26
Seller	Ten-period Costless delay	$46.73 (7.62)	$-3.46 (11.06)	$16.73 (7.61)	$10.43 (5.02)	$9.28 (3.38)	N = 30
Seller	Ten-period Costly delay	$44.17 (6.86)	$1.65 (8.94)	$14.17 (6.86)	$9.39 (4.90)	$7.80 (2.96)	N = 30

Table 2. Probit regression results for responders' decisions (marginal effects, *dF/dx*, for the probability of acceptance are reported)

	Buyer-Offer Treatments	Seller-Demand Treatments
Offer/demand	0.055***	-0.063***
Single-period	0.370***	0.580***
Costless delay	-0.381**	-0.244***
N =	176	172
Pseudo R^2 =	0.388	0.583
Prob > χ^2 =	0.000	0.000

*** Significant at the 1% level

** Significant at the 5% level

Table 3. Holdout and efficiency results

Proposer	Treatment	Percent of first-period rejections	Mean Holdout (Total rejections per group)	Number of failed agreements	Efficiency	Number of groups
Buyer	Single Period	25.9%	NA	12	58.6%	N = 29
Buyer	Ten-period Costless delay	96.6%	10.8	0	100%	N = 29
Buyer	Ten-period Costly delay	66.7%	2.9	0	85.3%	N = 30
Seller	Single Period	15.4%	NA	6	76.9%	N = 26
Seller	Ten-period Costless delay	91.7%	11.0	1	96.7%	N = 30
Seller	Ten-period Costly delay	71.7%	3.3	0	83.3%	N = 30

8. Figure Captions

Figure 1. Probability of sellers accepting a given offer

Figure 2. Probability of buyers accepting a given demand

Figure 3. Change in real offers (to sellers) by period[15]

Figure 4. Change in real offers (to buyers) by period[16]

9. Figures

Figure 1.

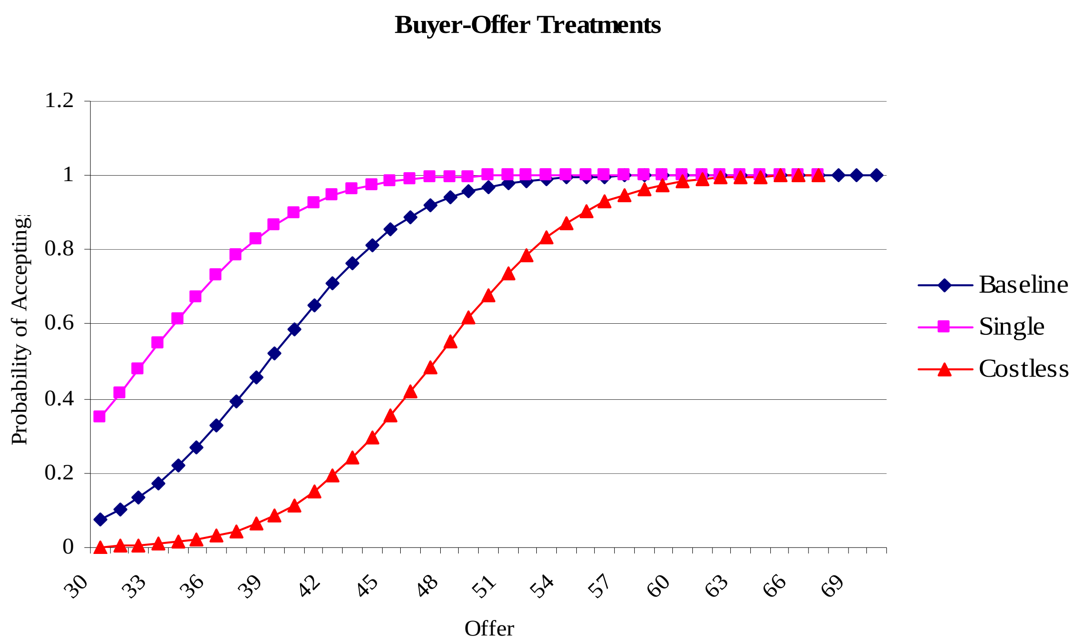


Figure 2.

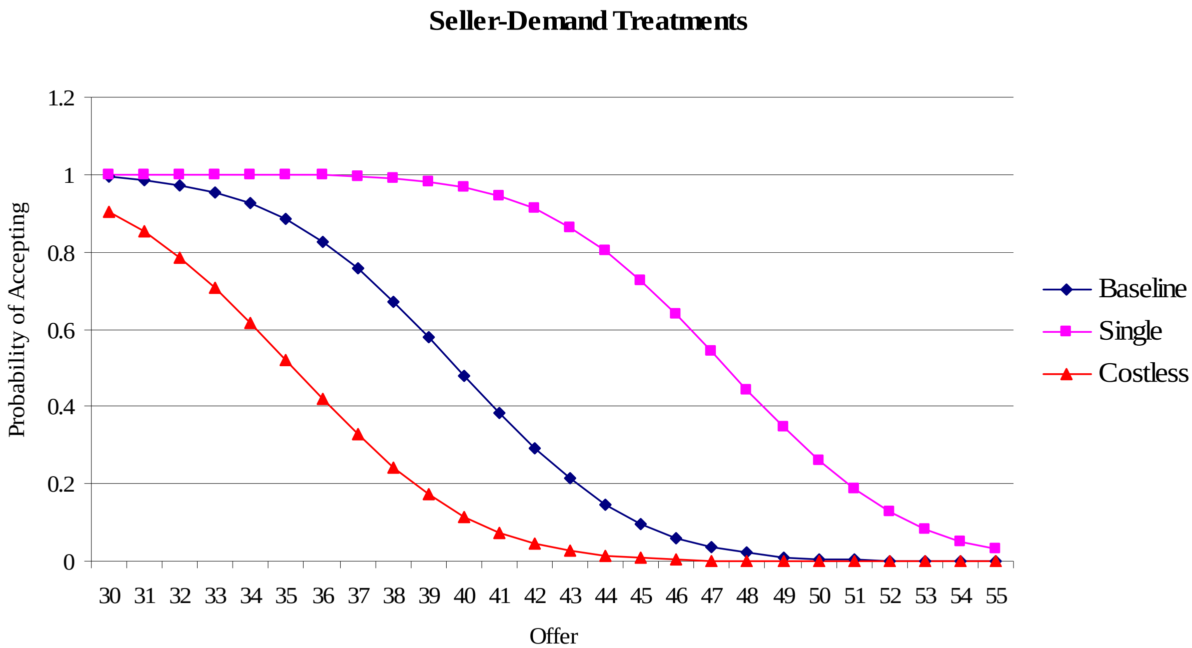
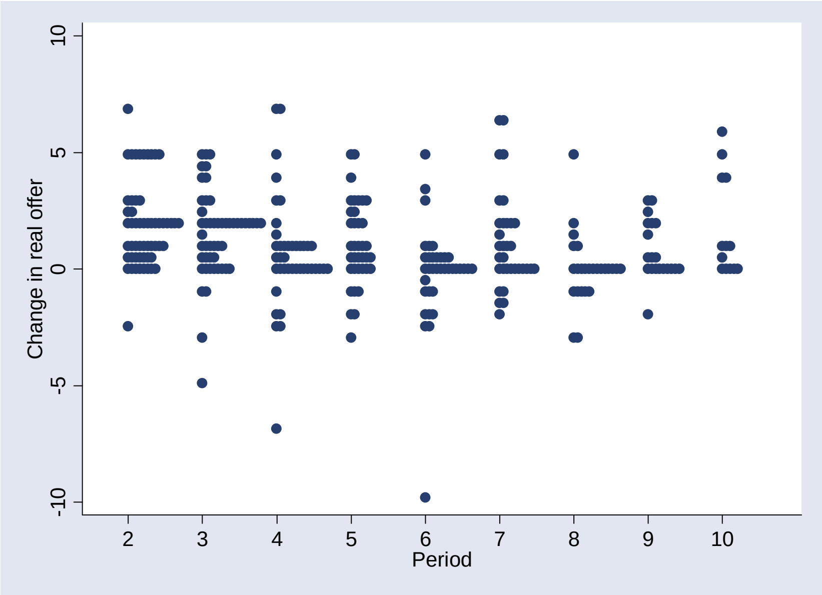
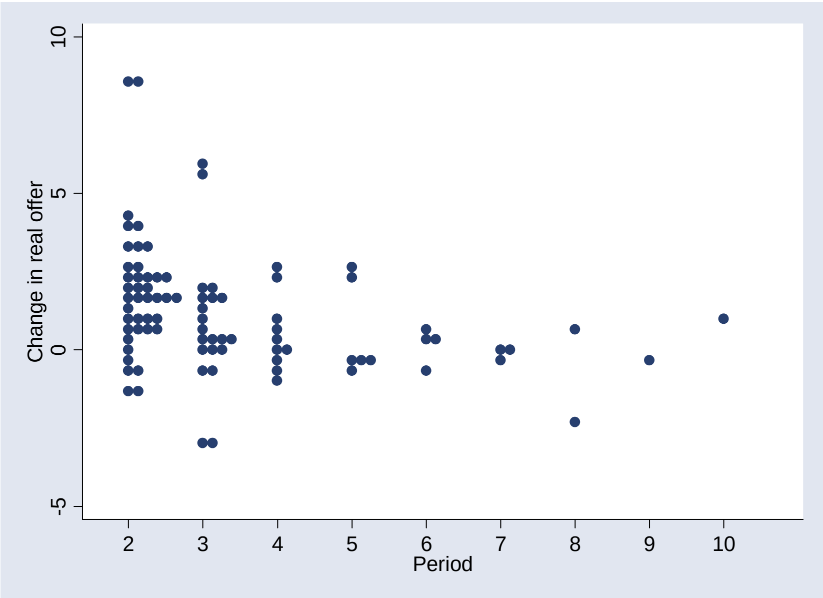

Seller-Demand Treatments
1.2
1
0.8
0.6
0.4
0.2
0
Probability of Accepting
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
Offer
Baseline
Single
Costless

Figure 3.

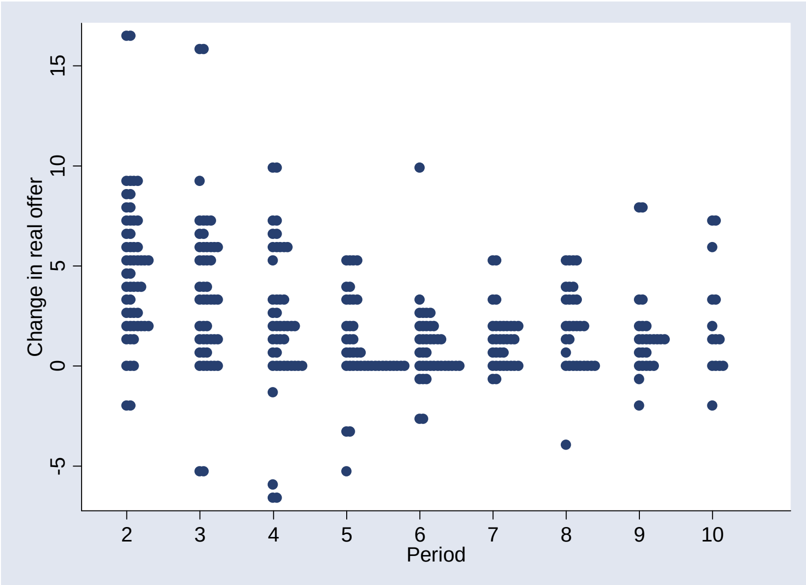


(a) Buyer offer, costless delay treatment

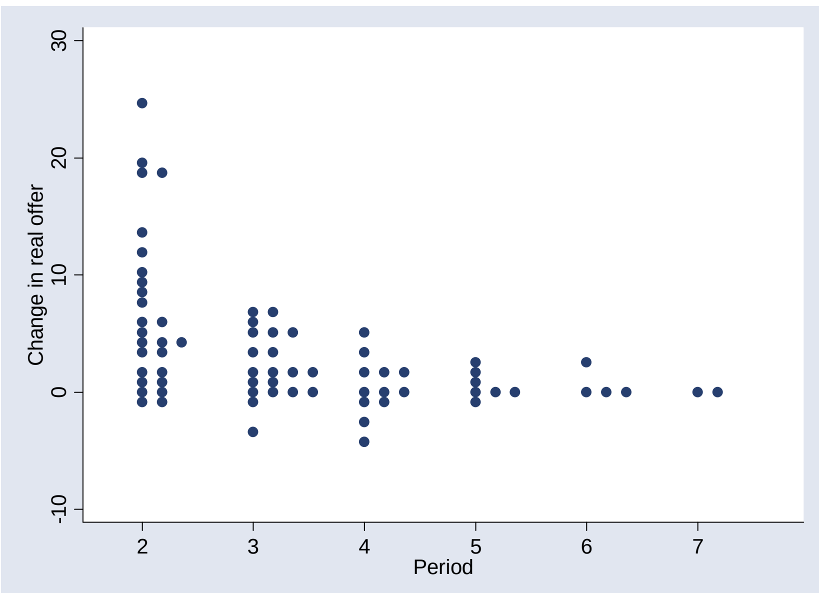


(b) Buyer offer, costly delay treatment

Figure 4.



(a) Seller offer, costless delay treatment



(b) Seller offer, costly delay treatment

[1] Eminent domain is also called compulsory purchase, compulsory acquisition, or expropriation.

[2] See *Kelo v. City of New London* (2005) for a recent example.

[3] See Munch (1975), Blume, Rubinfeld, and Shapiro (1984), Hermalin (1995), and Nosal (2001, 2007) for more on eminent domain and compensation.

[4] The one exception is Tanaka (2007).

[5] Under Nash bargaining, all parties submit a demand for their share of the surplus. If the sum of the demands is less than or equal to the surplus, each party is paid their demand. If the sum of the demands exceeds the surplus, all parties receive zero.

[6] Technically, each seller is indifferent between accepting or rejecting. Therefore, accepting is a weakly dominant strategy and, therefore, constitutes a best-response. One could alternatively assume that $b_i = c_i + \varepsilon$, where ε is the smallest unit of account available (one cent in our experiment). In this case each seller earns a small surplus by accepting. For simplicity, we assume that $\varepsilon \to 0$ in the limit and proceed without the more cumbersome notation.

[7] Using Wilcoxon Signed Ranks Test, all one-tailed significance levels < 0.015.

[8] Using Mann-Whitney Test, two-tailed significance level = 0.000. All statistical comparisons across treatments use Mann-Whitney Tests. All within treatment comparisons follow a Wilcoxon Signed Ranks Test.

[9] Two-tailed significance level = 0.000.

[10] Two-tailed significance levels = 0.002 and 0.030, respectively.

[11] One-tailed significance level = 0.007.

[12] Two-tailed significance level = 0.004.

[13] Using Wilcoxon Signed Ranks Test, all two-tailed significance levels < 0.022.

[14] Using Mann-Whitney Test, two-tailed significance level = 0.000 in each case.

[15] Shown is the real surplus offered by buyers to sellers.

[16] Shown is the real buyer's surplus that resulted from the joint demands made by sellers.